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1927/28

CLEVELAND COLLEGE

OF

WESTERN RESERVE UNIVERSITY

IN AFFILIATION WITH

CASE SCHOOL OF APPLIED SCIENCE

COURSES IN

CHEMISTRY, ENGINEERING
AND PHYSICS

1927-1928

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COLLEGE CALENDAR

1927

September 19-24	Registration for the first half-year
September 26	Opening of the first term
November 24-27	Thanksgiving recess
December 18	Beginning of the Christmas recess

1928

January 1	Close of the Christmas recess
January 30- February 4	{ Final examinations for the first half-year { Registration for the second half-year
February 6	Opening of the second term
February 22	Washington's Birthday—a holiday
May 30	Memorial Day—a holiday
May 28-June 2	Final examinations for the second half-year

Members of the faculty will be at the College every evening after five during September to confer with students wishing information or advice.

ADMINISTRATIVE OFFICERS

- ROBERT ERNEST VINSON, D.D., LL.D., *President.*
ALEXANDER CASWELL ELLIS, Ph.D., *Director.*
FRITZ WILLIAM GRAFF, A.B., M.B.A., *Assistant to the Director.*
FRANCES MILDRED GILLIS, Ph.B., *Registrar.*
HAROLD SIMMONS BOOTH, Ph.D., *Head of the Division of Physical Sciences.*
HENRY BALDWIN DATES, E.E., *Head of the Division of Engineering.*

FACULTY

- HERACLIO ALFARO, *Lecturer in Aeronautical Engineering.*
ERIC ANDERSON ARNOLD, M.S., *Instructor in Chemistry.*
HAROLD SIMMONS BOOTH, Ph.D., *Assistant Professor of Chemistry and Head of the Division of Physical Sciences.*
HERBERT MELLVILLE BOYLSTON, A.M., Met.E., *Professor of Metallurgy.*
RICHARD STEVENS BURLINGTON, A.M., *Instructor in Mathematics.*
HARRY DEWARD CHURCHILL, C.E., *Assistant Professor of Mechanics.*
CHARLES WILLIAM COPPERSMITH, M.E., *Associate Professor of Machine Design.*
RAYMOND HEWES DANFORTH, B.S., M.E., *Professor of Mechanics and Hydraulics.*
HENRY BALDWIN DATES, E.E., *Professor of Electrical Engineering and Head of the Division of Engineering.*
MALCOLM STEWART DOUGLAS, B.S., *Instructor in Civil Engineering.*
JOHN HENRY DYBLE, B.S., *Instructor in Mechanics.*
HIPPOLYTE GRUENER, Ph.D., *Professor of Chemistry.*
SETH HAYES, A.M., *Lecturer in Chemistry.*
FRANK HOVORKA, Ph.D., *Instructor in Chemistry.*
ERNEST LEE JACKSON, Ph.D., *Assistant Professor of Chemistry.*
ANTHONY JENKIN, B.S., *Associate Professor of Mining Engineering.*

NORBERT ADOLPH LANGE, PH.D., *Assistant Professor of Organic Chemistry.*

CLYDE ALEXANDER McKEEMAN, B.S., *Instructor in Mechanical Engineering.*

JOHN RICHARD MARTIN, M.S., *Assistant Professor of Physics.*

JOHN ELLSWORTH MERRILL, A.B., M.S., *Instructor in Mathematics.*

MAX MORRIS, A.M., *Assistant Professor of Mathematics.*

LEVI BUSHNELL MUMMA, A.B., B.S., *Instructor in Mechanical Engineering.*

WILLARD EUGENE NUDD, B.S., *Assistant Professor of Drawing and Descriptive Geometry.*

CHRISTIAN NUSBAUM, PH.D., *Assistant Professor of Physics.*

CARL FREDERICK PRUTTON, M.S., *Assistant Professor of Chemistry.*

RUSSELL CALDWELL PUTNAM, B.S., *Instructor in Electrical Engineering.*

WILLIAM ERNEST RICE, *Associate Professor of Municipal Engineering.*

OLIVER MARLOW STONE, A.B., M.S., *Assistant Professor of Drawing and Descriptive Geometry.*

OLIN FREEMAN TOWER, PH.D., *Hurlbut Professor of Chemistry and Director of the Chemical Laboratory.*

FRED HALE VOSE, M.E., *Professor of Mechanical Engineering.*

GERALD WILLIAM WAGNER, M.S., *Instructor in Chemistry.*

COURSES OF INSTRUCTION

The following is a statement of the courses in chemistry, engineering, and physics that are being offered by Cleveland College for 1927-1928.

Students wishing to register for courses in chemistry for graduate credit should consult the bulletin of the Graduate School.

A complete catalogue of Cleveland College will be mailed upon request.

CHEMISTRY

Chemistry 1 and 4 are the equivalent of the freshman course in chemistry in Adelbert College and the College for Women, and Chemistry 1, 2, and 4 are the equivalent of the freshman course in chemistry at Case School of Applied Science.

Students are advised to take Chemistry 2 and Chemistry 4 simultaneously.

Students planning to major in chemistry should plan their schedules so as to follow Chemistry 1, 2, and 4 with Chemistry 5 and 6, then with Chemistry 8a and 8b, and then with Chemistry 9 and 10. These courses may be considered in their respective fields fundamental to sound work in chemistry. Courses 5 and 8a, and 6 and 8b are so scheduled that they may be taken simultaneously.

UNDERGRADUATE COURSES

1f-4. General Inorganic Chemistry. Four hours of credit.

[FIRST TERM]

A course designed both for beginners in chemistry and for those who have had chemistry in high-school. A study of the non-metallic elements and of the fundamental principles of chemistry. Three hours of lecture, recitation, and problem study and three hours of laboratory a week.

Monday and Friday, 7:00-10:00 P.M.

Tuition, \$40.00; laboratory fee, \$4.00. Mr. ARNOLD and Mr. HAYES.

2s-2. Chemistry for Engineers. Two hours of credit.

[SECOND TERM]

The application of chemistry to the needs of the plant manager, designing engineer, architect-builder, and general manufacturer. Among the topics treated are: boiler-room chemistry, including water and its softening, fuels of all kinds, lubricants, gas-engine fuels, antiknock compounds, antifreeze preparations; materials of construction, such as cement, stone, wood, steel, brick, glass; soaps and industrial cleansing agents; protective coatings, including the problem of corrosion, paints, varnishes, enamels, metallic coatings; road-making materials; water supply and

purification; cutting and welding of metals; heavy chemicals. Two hours of lecture a week.

Prerequisite: Chemistry 1 and 4 or their equivalent. Students registering for Chemistry 4 are advised to take this course simultaneously.

Required of students planning to go to Case School of Applied Science.

Monday and Friday, 6:00-7:00 P.M.

Tuition, \$20.00.

Professor PRUTTON.

4s-4. Qualitative Analysis and Chemistry of the Metals. Four hours of credit. [SECOND TERM]

A systematic study of the metallic and non-metallic ions and the qualitative determination of simple mixtures; a practical study of the chemistry of the metals, accompanied by two meetings a week for discussion of the theory involved and for study of problems. Six hours of laboratory a week.

Prerequisite: Chemistry 1f.

Monday, Wednesday, and Friday, 7:00-10:00 P.M.

Tuition, \$40.00; laboratory fee, \$7.00; deposit, \$3.00.

Mr. ARNOLD and Mr. HAYES.

5f-3. Organic Chemistry. Three hours of credit. [FIRST TERM]

A study of the occurrence, chemical structure, preparation, properties, and general relationships of the compounds of the aliphatic series of hydrocarbons. Two hours of lecture or recitation and three hours of laboratory a week.

Prerequisite: A year of elementary college chemistry.

Monday and Friday, 7:00-8:00 P.M.; Wednesday, 7:00-10:00 P.M.

Tuition, \$30.00; laboratory fee, \$7.00; deposit, \$3.00.

Professor JACKSON and Professor LANGE.

6s-3. Organic Chemistry. Three hours of credit. [SECOND TERM]

A discussion of the carbohydrates, unsaturated compounds, aromatic series, heterocyclic and multinuclear compounds, and dyes, including laboratory preparation of typical representatives. Two hours of lecture or recitation and three hours of laboratory a week.

Prerequisite: Chemistry 5 or its equivalent.

Monday and Friday, 7:00-8:00 P.M.; Wednesday, 7:00-10:00 P.M.

Tuition, \$30.00; laboratory fee, \$7.00; deposit, \$3.00.

Professor JACKSON and Professor LANGE.

9f-3. Gravimetric Quantitative Analysis. Three hours of credit.

[FIRST TERM]

The exercises include the calibration of analytical weights, the determination of the most important ions by gravimetric methods, stoichiometrical calculations and applications of the mass law and of the theory of ionization to saturated solutions; frequent classroom meetings for dis-

cussion of the laboratory work and reports on problems. Nine hours of laboratory a week.

Prerequisite: Chemistry 4 or its equivalent.

Monday, Wednesday, and Friday, 7:00-10:00 P.M.

Tuition, \$30.00; laboratory fee, \$8.00; deposit, \$3.00.

Professor BOOTH and Mr. WAGNER.

10s-3. **Volumetric Quantitative Analysis.** Three hours of credit.

[SECOND TERM]

The calibration of volumetric apparatus; the theory of indicators; comprehensive review of oxidation and reduction reactions; problems involving normal and molar concentrations; combining weights and reports on other methods of analysis; laboratory work involving the preparation of standard solutions and determinations, adapted as much as possible to the needs of the individual; frequent classroom meetings for discussion of the laboratory work and reports on problems. Nine hours of laboratory a week.

Prerequisite: Chemistry 9 or its equivalent.

Monday, Wednesday, and Friday, 7:00-10:00 P.M.

Tuition, \$30.00; laboratory fee, \$8.00; deposit, \$3.00.

Professor BOOTH and Mr. WAGNER.

COURSES GIVING GRADUATE CREDIT

8a-3. **Elementary Physical Chemistry.** Three hours of credit.

[FIRST TERM]

A study of physical laws as applied to chemistry. The subject-matter includes: gases, liquids, and solids; solutions; thermochemistry; reaction velocity; electrochemistry; equilibrium; phase rule; and hydrogen ion concentration. A brief study is also made of modern conceptions of the atom and of radioactive phenomena.

The laboratory experiments illustrate and emphasize the principles that are simultaneously considered in the classroom by giving the student a concrete picture of the underlying phenomena. Among other experiments are the following: the determination of molecular weights, viscosity, surface tension, reaction velocity, equilibrium constants, electrical conductivity of solutions, transference numbers, electromotive forces, and electrometric titration. Two hours of lecture and three hours of laboratory a week.

Prerequisite: Nine hours of credit in college chemistry.

Monday and Wednesday, 8:00-9:00 P.M.; Tuesday, 7:00-10:00 P.M.

Tuition, \$30.00; laboratory fee, \$7.00; deposit, \$3.00. Dr. HOVORKA.

8b-3. **Elementary Physical Chemistry.** Three hours of credit.

[SECOND TERM]

A continuation of the work of the first half-year.

Prerequisite: Chemistry 8a.

Monday and Wednesday, 8:00-9:00 P.M.; Tuesday, 7:00-10:00 P.M.

Tuition, \$30.00; laboratory fee, \$7.00; deposit, \$3.00. Dr. HOVORKA.

12s-3. Chemical Microscopy. Three hours of credit.

[SECOND TERM]

A general course involving the use of the microscope and its accessories; microchemical methods as applied to chemical research; industrial applications; training in photomicrography and ultramicroscopy; introduction to microqualitative analysis. One hour of lecture and eight hours of laboratory a week.

Prerequisite: One and a half years of college chemistry.

Monday, Wednesday, and Friday, 7:00-10:00 P.M.

Tuition, \$30.00; laboratory fee, \$7.00; deposit (not returnable), \$3.00.

Professor BOOTH.

15s-3. Physicochemical Methods of Research. Three hours of credit.

[SECOND TERM]

This course is intended not only for advanced students who desire to survey the field but also for the investigator who wishes to know the physicochemical methods which have been applied to solve particular types of problems. The subjects discussed will be treated extensively in order to illustrate more fully the general principles of precise measurements. Topics discussed will, among others, include: the laboratory and its equipment, experimental errors, general operation, physical measurements, some properties of solutions, gases and vapors, thermochemistry, optical measurements, electrical properties, rate of reaction, x-ray analysis.

Prerequisite: Physical Chemistry and Calculus.

Monday and Friday, 8:00-9:30 P.M.

Tuition, \$30.00.

Dr. HOVORKA.

Not offered in 1927-1928.

17f-2. Technically Important Organic Syntheses. Two hours of credit.

[FIRST TERM]

A discussion of the reactions involved in synthetic methods of industrial organic chemistry, together with the theory involved. The course will emphasize the modern trend of organic chemistry away from the old empirical methods toward the new and exact synthetic processes. Two hours of lecture a week.

Prerequisite: Chemistry 5 and 6 or their equivalent.

Monday and Wednesday, 6:00-7:00 P.M.

Tuition, \$20.00.

Professor LANGE.

18s-3. Chemistry of Colloids. Three hours of credit.

[SECOND TERM]

The nature, preparation, and general behavior of colloidal substances. Three hours of lecture a week with demonstrations.

Prerequisite: A half-year of organic chemistry.

Wednesday and Friday, 8:00-9:30 P.M.

Tuition, \$30.00; materials fee, \$5.00.

Professor TOWER.

Not offered in 1927-1928.

19f-3. Electrochemistry. Three hours of credit. [FIRST TERM]

An experimental study of the principles of electrochemistry under the following main topics: study of instruments, electrochemical series, Faraday's laws, electromotive force, decomposition voltage, over-voltage, current density, polarization and film formation; electroplating, electrometallurgy and refining, electroanalysis, and corrosion of metals; electrochemical preparation of inorganic and organic compounds. Comprehensive reports both on laboratory work and on assigned topics. Nine hours of laboratory a week, with frequent conferences with the instructor, either individually or as a class.

Prerequisite: Qualitative and Quantitative Analysis, Organic Chemistry, and Elementary Physics.

Monday, Wednesday, and Friday, 7:00-10:00. P.M.

Tuition, \$30.00; laboratory fee, \$10.00; deposit, \$3.00.

Not offered in 1927-1928.

23f-0. Glass-Blowing and Apparatus-Building. No college credit.

[FIRST TERM]

A non-credit course in the simpler operations of glass-blowing to meet the needs of teachers of chemistry and physics as well as of research chemists.

Although prerequisite for those registering for research in the chemistry of gases, the course may be taken simultaneously with the research work by special arrangement.

Prerequisite: A year of elementary college chemistry.

Wednesday, 7:00-10:00 P.M.

Tuition, \$10.00; laboratory fee, \$7.00.

Professor BOOTH.

Not offered in 1927-1928.

25f-3. Thermodynamics Applied to Chemistry. Three hours of credit. [FIRST TERM]

The fundamental principles of thermodynamics which are particularly applicable to chemistry. Among the topics discussed are the first and second laws of thermodynamics and their application to fusion, evaporation, phase-rule, chemical equilibrium, chemical affinity electromotive force, and the third law with its applications. Three hours of lecture and recitation a week.

Prerequisite: Chemistry 8 and Elementary Calculus.

Monday and Friday, 8:00-9:30 P.M.

Tuition, \$30.00.

Dr. HOVORKA.

Not offered in 1927-1928.

114s-3. Advanced Chemical Microscopy. Three hours of credit.

[SECOND TERM]

A continuation of microqualitative analysis; special topics to suit the needs of individual students in microscopy of foods, fibres, enamels, paints, paper, technical products, rubber, and structural materials. Nine hours of laboratory a week.

Prerequisite: Chemistry 12 or its equivalent in experience.

Monday, Wednesday, and Friday, 7:00-10:00 P.M.

Tuition, \$30.00; laboratory fee, \$7.00; deposit (not returnable), \$3.00.

Professor BOOTH.

131f-3. **Research.** Three hours of credit.

[FIRST TERM]

Research in inorganic, organic, and physical chemistry for students adequately prepared. The laboratory offers special facilities for work with gases, their preparation, purification, study of their reactions, and measurement of certain of their physical constants; and for work in electrochemistry and chemical microscopy. Nine hours of laboratory a week.

Monday, Wednesday, and Friday, 7:00-10:00 P.M.

Tuition, \$30.00; laboratory fee, \$15.00; deposit, \$3.00.

Professor BOOTH, Professor JACKSON, and Dr. HOVORKA.

132s-3. **Research.** Three hours of credit.

[SECOND TERM]

A continuation of Chemistry 131f.

Monday, Wednesday, and Friday, 7:00-10:00 P.M.

Tuition, \$30.00; laboratory fee, \$15.00; deposit, \$3.00.

Professor BOOTH, Professor JACKSON, and Dr. HOVORKA.

GRADUATE COURSES OFFERED DURING THE DAY

101f-2. **Advanced Physical Chemistry.** Two hours of credit.

[FIRST TERM]

A seminar course dealing with selected topics in physical chemistry.

Prerequisite: Elementary Physical Chemistry and Calculus.

Tuesday and Friday, 5:00-6:00 P.M.

Tuition, \$17.00.

Professor TOWER.

102s-2. **Radioactivity and the Structure of the Atom.** Two hours of credit.

[SECOND TERM]

A seminar course consisting of two one-hour meetings a week.

Prerequisite: Elementary Physical Chemistry and Calculus.

Tuesday and Friday, 5:00-6:00 P.M.

Tuition, \$17.00.

Professor TOWER.

105f-1. **Sanitary Chemistry.** One hour of credit.

[FIRST TERM]

The problems of contamination and purification of water supplies; disposal of wastes.

Prerequisite: The consent of the instructor.

Thursday, 5:00-6:00 P.M.

Tuition, \$8.50.

Professor GRUENER.

106s-3. **Foods and Nutrition.** Three hours of credit.

[SECOND TERM]

Three one-hour meetings a week for lecture and discussion.

Prerequisite: The consent of the instructor.

Monday, Wednesday, and Thursday, 5:00-6:00 P.M.

Tuition, \$25.00.

Professor GRUENER.

111f-1. **Experimental Study of Gases.** One hour of credit.

[FIRST TERM]

A seminar course dealing with the methods of studying and manipulating gases.

Prerequisite: The consent of the instructor.

Saturday, 3:00-4:00 P.M.

Tuition, \$8.50.

Professor BOOTH.

112s-1. **The Chemistry of Gases.** One hour of credit.

[SECOND TERM]

A seminar course dealing with the history, preparation, purification, and physical and chemical properties of gaseous substances.

Prerequisite: The consent of the instructor.

Saturday, 3:00-4:00 P.M.

Tuition, \$8.50.

Professor BOOTH.

ENGINEERING
APPLIED MECHANICS

1f-4. Mechanics. Four hours of credit.

[FIRST TERM]

A treatment of the fundamental laws of force, mass, and motion, beginning with the study of statics; the algebraic and graphical solution of problems involving the resolution and composition of forces, the finding of the center of gravity of areas and solids, and the application of the principles of equilibrium to flexible cords, jointed frames, etc.; the study of motion, uniform and accelerated, rectilinear and curvilinear; the consideration of force, mass, and acceleration, the laws of work and energy, and the principles of impulse and momentum.

Prerequisite: Mathematics 23a and 23b and Physics 2a and 2b.

Tuesday and Thursday, 7:30-9:30 P.M.

Tuition, \$40.00.

Professor CHURCHILL or Mr. DYBLE.

3s-1. Testing Laboratory for Strength of Materials. One hour of credit.

[SECOND TERM]

A course consisting of a series of experiments on the tensile, compressive, transverse, torsional, and columnar strengths of the principal materials of engineering, the work of each experiment being performed by the student under the supervision of an instructor, who endeavors to teach good laboratory methods as well as a knowledge of the properties of the materials. A report on each experiment must be presented in acceptable form by the student.

The laboratory includes the following testing machines, with complete outfits of extensometers, deflectometers, micrometers, and other instruments and apparatus: An Olsen 200,000-pound, a Riehle 100,000-pound, a Riehle 60,000-pound, an Olsen 30,000-pound, an Olsen 10,000-pound universal testing machine; a 50,000-inch-pound Olsen torsion testing machine; a Riehle hydraulic transverse machine with a capacity of 100,000 pounds center load, one of the largest ever constructed and capable of testing specimens up to twenty feet in length. To study the property of hardness, of greatest importance in the newer alloy steels, the laboratory has a Brinnell hardness tester and scleroscope, a Rockwell machine, and several special devices for testing abrasive hardness of steel rails, etc., and a new American-made Charpy impact and shock testing apparatus. To insure the accuracy of these various testing machines, the laboratory has three independent sets of standardizing and calibrating apparatus, two of which are in regular use by students, who check the accuracy of each machine in the laboratory at frequent intervals. The third set of standard apparatus is retained as a final reference standard.

Prerequisite: Strength of materials.

Tuesday, 7:30-9:30 P.M.

Tuition, \$10.00; laboratory fee, \$5.00.

Professor DANFORTH and Assistants.

CHEMISTRY

2s-2. Chemistry for Engineers. Two hours of credit. [SECOND TERM]

The application of chemistry to the needs of the plant manager, designing engineer, architect-builder, and general manufacturer. Among the topics treated are: boiler-room chemistry, including water and its softening, fuels of all kinds, lubricants, gas-engine fuels, antiknock compounds, antifreeze preparations; materials of construction, such as cement, stone, wood, steel, brick, glass; soaps and industrial cleansing agents; protective coatings, including the problem of corrosion, paints, varnishes, enamels, metallic coatings; road-making materials; water supply and purification; cutting and welding of metals; heavy chemicals. Two hours of lecture a week.

Prerequisite: Chemistry 1 and 4 or their equivalent. Students registering for Chemistry 4 are advised to take this course simultaneously.

Required of students planning to go to Case School of Applied Science.

Monday and Friday, 6:00-7:00 P.M.

Tuition, \$20.00.

Professor PRUTTON.

DRAWING

1a-2. Engineering Drawing. Two hours of credit. [FIRST TERM]

The use of drafting instruments; orthographic projection; freehand lettering; freehand technical sketching; pencil mechanical drawing; tracing; sketching from machine parts; use of reference books and prints; isometric and cabinet drawing. Lectures on theory and commercial practice.

Tuesday and Thursday, 6:00-8:00 P.M.

Tuition, \$20.00.

Professor STONE or Professor NUDD.

1b-2. Engineering Drawing. Two hours of credit. [SECOND TERM]

A continuation of the work of the first half-year.

Prerequisite: Drawing 1a.

Tuesday and Thursday, 6:00-8:00 P.M.

Tuition, \$20.00.

Professor STONE or Professor NUDD.

2a-2. Descriptive Geometry. Two hours of credit. [FIRST TERM]

The graphical solution of problems on the point, line, and plane, followed by the graphical solution of spherical triangles and other practical applications as time permits.

Tuesday and Thursday, 6:00-9:00 P.M.

Tuition, \$20.00.

Professor STONE or Professor NUDD.

2b-2. Descriptive Geometry. Two hours of credit. [SECOND TERM]

A continuation of the work of the first half-year.

Prerequisite: Drawing 2a.

Tuesday and Thursday, 6:00-9:00 P.M.

Tuition, \$20.00.

Professor STONE or Professor NUDD.

MATHEMATICS

2f-3. Algebra. Three hours of credit. [FIRST TERM]

A course for students electing mathematics who need further instruction in algebra. A thorough review of the fundamentals of algebra through progressions, with emphasis on the theory of exponents; systems of simultaneous equations, linear and quadratic.

Prerequisite: Two years of high-school mathematics.

Tuesday and Thursday, 8:00-9:30 P.M.

Tuition, \$30.00.

Mr. BURINGTON.

21a-4½. Engineering Mathematics. Four and a half hours of credit. [FIRST TERM]

A course intended to benefit alike students who aim to use it as a preparation for studies in engineering and science and those who wish to round out their mathematical training. General algebraic principles; trigonometric functions; measurement of angles; solution of equations by means of trigonometry and graphs; use of logarithmic tables and solution of triangles; spherical trigonometry; rectangular and polar coordinates; equations of the first and second degree; graphs and empirical equations; coordinates in space; the plane; and surfaces of the second order.

Prerequisite: A year and a half of algebra, a year of plane geometry, and a half-year of solid geometry.

Monday, Wednesday, and Friday, 8:00-9:30 P.M.

Tuition, \$45.00.

Mr. MERRILL.

21b-4½. Engineering Mathematics. Four and a half hours of credit. [SECOND TERM]

A continuation of the work of the first half-year.

Prerequisite: Mathematics 21a or its equivalent.

Monday, Wednesday, and Friday, 8:00-9:30 P.M.

Tuition, \$45.00.

Mr. MERRILL.

23a-4. Calculus. Four hours of credit. [FIRST TERM]

A study of the principles of calculus and the application of those principles to practical problems. Differentiation of functions; geometric and physical meaning of the derivative; maxima and minima and rate problems; curve-plotting and application to mechanics; simple integration; single and multiple integrals; application of definite integral to length of arc, area, surface, volume, center of gravity, and moment of inertia; expansion of functions; computation of logarithms and trigonometric functions.

Prerequisite: Mathematics 21a and 21b or their equivalent.

Monday and Wednesday, 7:30-9:30 P.M.

Tuition, \$40.00.

Professor MORRIS.

23b-4. Calculus. Four hours of credit. [SECOND TERM]

A continuation of the work of the first half-year.

Prerequisite: Mathematics 23a or its equivalent.

Monday and Wednesday, 7:30-9:30 P.M.

Tuition, \$40.00.

Professor MORRIS.

PHYSICS

2a-6. General Physics. Six hours of credit. [FIRST TERM]

A course designed to furnish the basis for advanced work in physics and the engineering sciences; emphasis upon the mathematical treatment of the subject and the solution of problems. Four hours of lecture and recitation and four hours of laboratory a week.

Prerequisite: A year of high-school physics and Mathematics 21a and 21b (or their equivalent).

Monday, 7:00-10:00 P.M.; Wednesday, 7:00-9:00 P.M.; Friday, 7:00-10:00 P.M.

Tuition, \$60.00; laboratory fee, \$5.00.

Professor NUSBAUM.

2b-6. General Physics. Six hours of credit. [SECOND TERM]

A continuation of Physics 2a.

Prerequisite: A year of high-school physics and Mathematics 21a and 21b (or their equivalent).

Physics 2b may be taken before Physics 2a.

Monday, 7:00-10:00 P.M.; Wednesday, 7:00-9:00 P.M.; Friday, 7:00-10:00 P.M.

Tuition, \$60.00; laboratory fee, \$5.00.

Professor NUSBAUM.

AERONAUTICAL ENGINEERING

1f-2. The Elements of Aeronautical Engineering. Two hours of credit. [FIRST TERM]

A course in the general principles of aeronautics, designed to lay a foundation for advanced work in the subject and to provide preparation for an intelligent consideration of some of the important problems involved in airplane design.

Prerequisite: A knowledge of algebra, general physics, and the elements of mechanical engineering.

Wednesday, 7:30-9:30 P.M.

Tuition, \$20.00.

Mr. ALFARO.

2s-2. Airplane Design. Two hours of credit. [SECOND TERM]

The use of foundation acquired in Aeronautical Engineering 1f for making practical estimates of airplane performance and airplane characteristics. Different typical examples are worked out during the course.

Prerequisite: Aeronautical Engineering 1f or its equivalent.

Wednesday, 7:30-9:30 P.M.

Tuition, \$20.00.

Mr. ALFARO.

3f-2. Structural Designing. Two hours of credit. [FIRST TERM]

A practical course in the designing of parts entering into the construction of airplanes. Practical designing of fittings, ribs, spars, welded structures, riveted joints, controls, etc., after the stresses to which the different members are subject have been determined. Practical examples are worked out during the course.

Prerequisite: Elements of algebra, machine drawing, and either practical designing experience or elementary applied mechanics.

It is advisable to take Aeronautical Engineering 1f and 3f at the same time.

Friday, 7:30-9:30 P.M.

Tuition, \$20.00.

Mr. ALFARO.

4s-2. **Airplane Designing.** Two hours of credit. [SECOND TERM]

Actual layout and preliminary drawings of an original type of airplane selected by the student. Three-view drawing of the machine and sketching of typical fittings and main structural parts to be worked out during the course.

Prerequisite: Aeronautical Engineering 1f and 3f.

Friday, 7:30-9:30 P.M.

Tuition, \$20.00.

Mr. ALFARO.

CIVIL ENGINEERING

1a-2. **Structural Design.** Two hours of credit. [FIRST TERM]

The determination by algebraic and graphic methods of the stresses in framed structures, both roof and bridge trusses, followed by the design of the sections of the members and the details of their connections.

Tuesday, 7:30-9:30 P.M.

Tuition, \$20.00.

Mr. DOUGLAS.

1b-2. **Structural Design.** Two hours of credit. [SECOND TERM]

A continuation of the work of the first half-year.

Prerequisite: Civil Engineering 1a.

Tuesday, 7:30-9:30 P.M.

Tuition, \$20.00.

Mr. DOUGLAS.

2a-2. **Reinforced Concrete Construction.** Two hours of credit.

[FIRST TERM]

The course covers the design of rectangular beams, slabs, girders, and columns. The use of diagrams in design will be studied. Proportioning concrete by the water-cement ratio theory as well as by the fineness modulus and other methods of proportioning aggregates will be covered in detail.

The student should have had a course in mechanics of structures before taking this course.

Thursday, 7:30-9:30 P.M.

Tuition, \$20.00.

Mr. DOUGLAS.

2b-2. **Reinforced Concrete Construction.** Two hours of credit.

[SECOND TERM]

A continuation of the work of the first half-year.

Prerequisite: Civil Engineering 2a.

Thursday, 7:30-9:30 P.M.

Tuition, \$20.00.

Mr. DOUGLAS.

3f-3. Highway Engineering. Three hours of credit. [FIRST TERM]

A course dealing with the principles of location, construction, and maintenance of highways. Instruction will include latest principles of design not only of surfaces but also of bases and subgrades. With reference to location, reconnaissance, preliminary, and final work will be covered. Under construction, complete working details, plant, organization of constructing force, materials, and inspection will be taken up for all standard types of roadway. Latest methods of repair and organization, with equipment needed, will be included in maintenance division. Problems designed to illustrate all necessary computations, including preliminary, periodical, and final estimates, will be discussed in the course of the classroom work.

Monday and Wednesday, 6:00-7:30 P.M.

Tuition, \$30.00.

Professor RICE.

4s-3. Sanitary Engineering. Three hours of credit. [SECOND TERM]

The course is designed to cover in a broad way the principles of design and location of sewers and sewage disposal plants and the construction of sewerage works. Preliminary work will include hydraulics of sewers, forecasting of populations, and planning of sewer systems with reference to street layouts. Under construction, complete working details, plant, organization of forces, materials, and inspection will be taken up. Sewerage systems, including separate, storm, and combined, will be discussed, using rational method of design. With reference to disposal plants, latest principles of design and construction, plant and equipment, and all estimates and plans in connection therewith will be covered. Problems designed to illustrate these principles will be discussed throughout the course.

Monday and Wednesday, 6:00-7:30 P.M.

Tuition, \$30.00.

Professor RICE.

ELECTRICAL ENGINEERING

3f-4. Electrical Machinery—Direct Current. Four hours of credit.

[FIRST TERM]

A course dealing with direct-current circuits, apparatus, and machinery. The subjects treated include the fundamental electrical and magnetic laws of direct currents; the theory and practical operating characteristics and maintenance of storage batteries, direct-current instruments, various types of generators and motors, and the transmission and distribution of direct-current power. Manual and automatic starting devices for motors are studied, and special attention is given to questions pertaining to the selection of the most suitable type of machine or apparatus to meet a given set of requirements. The laboratory work is an integral part of the course, and illustrates principles stressed in the classroom.

Tuesday and Thursday, 6:00-9:00 P.M.

Tuition, \$40.00; laboratory fee, \$10.00.

Mr. PUTNAM.

4s-4. Electrical Machinery—Alternating Current. Four hours of credit. [SECOND TERM]

A course dealing with alternating-current circuits, apparatus, and machinery. The subjects treated include the fundamental electrical and magnetic laws of alternating currents; single-phase, two-phase, and three-phase circuits; the theory and practical operating characteristics and maintenance of alternating-current instruments, alternators, transformers, the various types of motors, converters, control apparatus, both manual and automatic, and the transmission and distribution of alternating-current power. Emphasis is placed upon the practical applications of the apparatus and machinery studied. The laboratory work is an integral part of the course, and illustrates important principles of the classroom work.

Tuesday and Thursday, 6:00-9:00 P.M.

Tuition, \$40.00; laboratory fee, \$10.00.

Mr. PUTNAM.

5f-2. The Principles of Illumination. Two hours of credit.

[FIRST TERM]

A practical course in the art and science of illumination, including the fundamental principles of illumination and photometry; illuminating gas, arc lamps, incandescent lamps, and vapor-tube lamps as light sources; light, shade, and color; daylight; residence lighting and the lighting of public buildings, commercial lighting, industrial lighting, sign and display lighting, street lighting, and light projection.

Friday, 6:00-9:00 P.M.

Tuition, \$20.00.

Professor DATES.

MECHANICAL ENGINEERING

5a-1. Machine Drawing. One hour of credit.

[FIRST TERM]

A graphical study of velocity relations and force relations in link work; the design of cams; methods of dimensioning drawings, including use of allowance and tolerance; a series of actual designs of machines to illustrate designing to facilitate molding, machining, and assembling.

Prerequisite: Drawing 1a and 1b.

Monday, 6:00-9:00 P.M.

Tuition, \$10.00.

Professor COPPERSMITH.

5b-1. Machine Drawing. One hour of credit.

[SECOND TERM]

A continuation of the work of the first half-year.

Prerequisite: Mechanical Engineering 5a.

Monday, 6:00-9:00 P.M.

Tuition, \$10.00.

Professor COPPERSMITH.

6a-3. Machine Design. Three hours of credit.

[FIRST TERM]

A study of the design of machines and machine parts, together with a consideration of the laws governing the motion and velocity of moving parts, the shape of cams and gear teeth, the materials to be used, the strength of the parts, and the forms and types best adapted to the machine under consideration from the standpoint of service, safety, appearance, and economic production. The following topics are studied:

angular and linear velocity relations, plain and epicyclic trains; relations among force, velocity, and power; energy stored in fly wheels; relations among force, stress, and strain; machine elements—screws and bolts; riveted and welded joints; keys, cotters, force and shrink fits; boilers, tanks, cylinders, unsupported and stayed heads; coil and leaf springs; journal, ball, and roller bearings; shafting; couplings and jaw clutches; friction clutches and brakes; belting and chain drives; hoisting rope, drums, sheaves, hooks; spur, bevel, spiral, and worm gears; cast, forged, and structural frames.

Tuesday and Thursday, 7:30-9:00 P.M.

Tuition, \$30.00.

Professor COPPERSMITH.

6b-3. **Machine Design.** Three hours of credit. [SECOND TERM]

A continuation of Mechanical Engineering 6a.

Students may begin the course with the work of the second half-year.

Tuesday and Thursday, 7:30-9:00 P.M.

Tuition, \$30.00.

Professor COPPERSMITH.

20f-3. **Thermodynamics of Gases and Vapors.** Three hours of credit.
[FIRST TERM]

A study of the effects produced by heat; the general laws of thermodynamics as applied to perfect gases, saturated and superheated vapors, and so on; isothermal and adiabatic expansion; temperature-entropy diagrams; the theoretical heat cycles for internal combustion engines; compressors and steam engines; the flow of gases and vapors through orifices and nozzles.

Monday and Wednesday, 6:00-7:30 P.M.

Tuition, \$30.00.

Mr. McKEEMAN or Mr. MUMMA.

45a-3. **Heat Power Engineering.** Three hours of credit.

[FIRST TERM]

This course is designed for those who wish to obtain a knowledge of the burning of fuel and the production of power in plants which use steam engines, steam turbines, or internal-combustion engines. It will start with a consideration of the fuels in general use (solid, liquid, and gaseous), and the burning of these fuels with various types of equipment. The steam power plant will be analyzed from the coal pile to the switch-board, both as to its thermal efficiency and as to its cost of operation. The internal-combustion engine plant will receive similar consideration. Standard methods of testing power-plant equipment will be discussed, together with the calculations necessary for the determination of the efficiency of the apparatus under test. A portion of the time will be devoted to the selection and proportioning of power-plant apparatus for specific purposes.

Monday and Wednesday, 8:00-9:30 P.M.

Tuition, \$30.00.

Professor VOSE.

45b-3. **Heat Power Engineering.** Three hours of credit.

[SECOND TERM]

A continuation of the work of the first half-year.

Prerequisite: Mechanical Engineering 45a.

Monday and Wednesday, 8:00-9:30 P.M.

Tuition, \$30.00.

Professor VOSE.

METALLURGICAL AND MINING ENGINEERING

1f-5. **Metallography.** Five hours of credit. [FIRST TERM]

A course dealing with metallographic apparatus and its manipulation in the laboratory and with the technology of metallography. A study of the structure of pure metals in general, of pure iron, wrought iron, steels with increasing amounts of carbon, impurities in steel, thermal critical points, cast steel, mechanical treatment, annealing, hardening, tempering, etc.; practice in the laboratory in the preparation of metallographic specimens to illustrate the lectures, each student being expected to prepare and examine about forty typical specimens of iron, steel, and other alloys, to perform heat treatment on them where called for, and to gain experience in photomicrography.

Prerequisite: The consent of the instructor.

Monday, 7:30-9:30 P.M.; Thursday, 6:30-9:30 P.M.

Tuition, \$50.00; laboratory fee, \$10.00.

Professor BOYLSTON and Professor JENKIN.

Offered in alternate years; not offered in 1927-1928.

2s-3. **The Metallurgy of Iron and Steel.** Three hours of credit.

[SECOND TERM]

A course designed to give a thorough knowledge of the fundamentals of the metallurgy of iron and steel, including their manufacture. A study of the historical and economic aspects of the iron and steel industry; chemical and physical principles; the raw materials of the iron industry, iron ore, fuels, limestone, and air; the blast furnace and the manufacture of pig iron; the iron and steel foundry; the manufacture of wrought iron; the early steel-making processes; the Bessemer process; the open-hearth process; electric furnaces in the iron and steel industry; the manufacture of commercially pure iron (ingot iron and electrolytic iron); ingots and ingot-making; the mechanical treatment of steel; the composition and structure of iron and steel; the heat treatment of steel.

Prerequisite: The consent of the instructor.

Wednesday, 6:30-9:30 P.M.

Tuition, \$30.00.

Professor BOYLSTON.

RADIO ENGINEERING

1f-4. **Radio Engineering.** Four hours of credit. [FIRST TERM]

In this course the student is given a broad survey of the theory of radio telegraphy and telephony, with special emphasis on the engineering phases of the work. The subjects considered are low frequency alternating current principles, properties of oscillatory circuits, antenna systems and wave propagation, damped and continuous wave transmission and reception, the vacuum tube and its applications, radio measurements and design.



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Prerequisite: A general knowledge of physics and electricity. A knowledge of calculus is desirable.

Tuesday and Thursday, 7:30-9:30 P.M.

Tuition, \$40.00.

Professor MARTIN.

PHYSICS

1a-4. College Physics. Four hours of credit. [FIRST TERM]

A general course in physics treating of the fundamental principles of the subject: mechanics of solids, liquids, and gases; heat and thermodynamics; wave-motion; sound; electricity and magnetism; light; and modern physics. Although the historical, descriptive, and practical aspects of the subjects are emphasized, the simpler mathematical developments are not omitted. Three hours of lecture and recitation and two hours of laboratory a week.

Monday, 7:00-10:00 P.M.; Wednesday, 7:00-9:00 P.M.

Tuition, \$40.00; laboratory fee, \$5.00.

Professor NUSBAUM.

1b-4. College Physics. Four hours of credit. [SECOND TERM]

A continuation of Physics 1a.

Physics 1b may be taken before Physics 1a.

Monday, 7:00-10:00 P.M.; Wednesday, 7:00-9:00 P.M.

Tuition, \$40.00; laboratory fee, \$5.00.

Professor NUSBAUM.

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